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Examining mechanisms of direct contribution, strengthening and reciprocal compensation between executive functions and visomotor integration in children's hand writing in second and third grades.

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Abstract

During the last few decades, the use of computers has been increasing. The computer has infiltrated almost every environment and element of our lives, as computers support, and sometimes replace, many human functions. However, handwriting is still an important skill that children must learn. Handwriting is closely related to cognitive, academic, and emotional functions; it predicts success across a wide range of academic skills and is a meaningful occupation for children. Handwriting is a key element in children's functioning and is important to their ability to work and participate in a variety of environments.

Learning to write is a difficult and complex process that requires considerable effort, since it entails a continuous interaction between basic perceptual-motor processes, such as motor planning and execution, and high-level cognitive processes, such as executive functions (EF). As motor processes become automatic, more attention can be devoted to higher-level processes. Working memory efforts devoted to handwriting that is not fluent interfere with higher processes, which are responsible for the content and complexity of the written expression. Likewise, handwriting skills may be impaired due to immature EF. Therefore, it is important to identify reinforcing mechanisms (in which the manifestation of one ability depends on the other) or compensatory mechanisms (in which one strong ability may compensate for another, weaker ability), which will improve the ability to promote writing skills through interventions that promote skills through other channels.

Little is known about how visuomotor integration (VMI) and elements of EF interact with each other, which could explain handwriting achievements in elementary school children. Moreover, given that both abilities derive from the same limited cognitive resources, it can be assumed that when the child has good VMI abilities, i.e., when these processes are more automatic and require less cognitive resources, the remaining cognitive resources can be directed toward activation of EFs.

This longitudinal study intends to support this assumption by investigating whether:

i) EF and VMI directly contribute to handwriting and its development (model of direct effect, in which each function contributes separately to the handwriting ability).

ii) EF and VMI depend on each other in the contribution to handwriting skills (model of reciprocal strengthening, in which the stronger one function is, the stronger the other function is the and stronger is its contribution as well).

iii) EF and VMI compensate for each other (model of compensation)

A sample of 170 second and third-graders from elementary schools in low socioeconomic status urban areas took part in this study. The handwriting skills that were evaluated in the second grade and again in third grade were: spelling and speed when writing to dictation as well as the extent of writing time required in a copying task. The children's VMI, as well as EFs (inhibition, working memory, and shifting ability), were evaluated in second grade.

The working hypotheses were:

i) Direct effects and interactions between VMI and EF will be found to predict handwriting skills.

ii) At least in some of the handwriting skills, compensation between VMI and EF will be found (negative interaction).

iii) The nature of the relations found between VMI and EF in the second grade will be different from those found in the third grade.

The main research findings were the identification of direct effects and reciprocal strengthening interactions between the research variables in predicting achievements in the writing tasks. With regard to direct effects in second grade, spelling accuracy in the writing to dictation task was predicted by the VMI variable and the working memory variable. The extent of writing time in a copying task was predicted by the VMI variable, and the writing speed in the writing to dictation task was predicted by the working memory variable.

In the third grade we examined the prediction ability of the variables above, the same ability which was assessed in second grade. The relations found between the variables in second and the third grade were of a different nature. The extent of writing time in a copying task was predicted by the VMI variable (with borderline significance) and by the working memory variable. The spelling in the dictation task was predicted by the shifting variable (with results of borderline significance) and the inhibition variable.

Furthermore, the current study identified reciprocal interactions. In second grade, we found a borderline significant reciprocal strengthening interaction between the working memory variable and the VMI variable in the coping task. In the third grade, the same reciprocal interaction became significant. In addition, a reciprocal strengthening interaction was found in the third grade between the shifting variable and the VMI variable in the spelling task.

These findings indicate that from second to third grade, the direct contribution of the VMI to the handwriting skills decreases and the contribution of the EF increases. On the other hand, the reciprocal strengthening interactions between EF and VMI, that better predicted writing skills in the third grade than in the second grade, demonstrates that in the third grade, EF and VMI contribute to writing skills not only in a direct manner, but also through their positive strengthening reciprocal correlations.